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Reliable critical care: making it easy to do the right thing

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Sir Muir Gray, Director of the NHS Chief Knowledge Office, hypothesized that ‘The application of what we know will have a bigger impact than any drug or technology likely to be introduced in the next decade.’ He recognized that blind investment in new drugs and technologies that provide only a modest improvement in efficacy may cost more lives than it saves, because this investment will consume scarce resources needed for improved delivery of care. Therefore, it can be argued from a health, economic, and moral standpoint that we should spend less on new technology and new drugs and more on improving systems for delivery of care1 and turning knowledge into action.

Whilst few of us would disagree that robust evidence from clinical trials should be implemented to improve patient care, it has become apparent that a gap exists and that the translation of evidence into routine practice is not as widespread and easily done as one would have expected. Evidence suggests that it takes on average 17 years for research evidence to reach clinical practice.2 This is a remarkably slow and inefficient process. Indeed, it took 13 years for cardiologists to recommend thrombolysis for the treatment of acute myocardial infarction after the publication of randomized controlled trials showed therapeutic benefit.3 Furthermore, Lomas and colleagues4 calculated a 5 year gap between publication of guidelines and changes to routine practice in Western health-care systems. Although the paucity of robust and high-quality evidence in critical care used to be cited as a reason for the lack of change in practice, critical care research in the last 10 years has been inundated with a number of practice-changing headlines, leaving clinicians with the responsibility of ensuring that these are incorporated into everyday practice to enable patients to receive safe, effective, and person-centred care.

In 2000, the acute respiratory distress syndrome (ARDS) network study demonstrated conclusively and unarguably that limiting tidal volume to <6 ml kg⁻¹ predicted body weight (PBW) and end-inspiratory pressure to not more than 30 cm H₂O, compared with patients ventilated with higher tidal volumes (>12 ml kg⁻¹ PBW), significantly reduces mortality in acute lung injury and ARDS, with a number needed to treat of 11 patients to save one life.5 No special equipment or expertise was required to achieve this benefit. Despite the perceived relative simplicity of implementing low-tidal volume ventilation, a number of studies published in the last 10 years reveal a disappointing failure of clinicians to adopt and implement this piece of evidence.6–8

In a simple yet elegantly designed and conducted service evaluation study in this issue of the BJA, Bourdeaux and colleagues5 have demonstrated how a large screen configured to display information routinely collected from a clinical information system resulted in a significant and sustained improvement in the use of evidence-based ventilation practice and reduced unwarranted tidal volume variation with improved reliability. In a mixed medical and surgical intensive care unit in a UK teaching hospital, two similar cohorts of patients on controlled mechanical ventilation after the publication of a guideline on low tidal volume ventilation showed a statistically significant difference between the use of this intervention for patients in the intervention group compared with the control group with respect to the proportion of patients who received the correct tidal volume (15%) in the intervention group compared with 5% in the control group. The results were consistent across different ventilator parameters, tidal volumes, and ventilator modes. The intervention group also had a significantly lower proportion of patients with near fatal clinical events such as cardiac arrest and severe acidosis compared with the control group. These results are consistent with those of a recent meta-analysis of systematic reviews and randomized controlled trials, which demonstrated that tidal volume limited to <6 ml kg⁻¹ PBW reduces mortality and adverse events compared with higher tidal volumes.9

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ventilation in two 6 month periods were studied, and data regarding the delivered tidal volumes were recorded and analysed. The intervention was simple. Two large (48 inch) display screens, which were visible to most staff working in the unit, were configured to display a number of metrics derived from the clinical information system database, including the tidal volume in milliliters per kilogram PBW, with real-time alerts if targets were breached. The authors observed that there was a significant increase in the time spent with tidal volumes <6 ml kg\(^{-1}\) (from 17.5 to 28.6%). The introduction of a large visual display with real-time alerts appears to be more effective in improving compliance than conventional audit processes where clinicians are presented with retrospective data highlighting non-compliance with expected standards.

Consequently, it is not only the timeliness of getting evidence into practice that is a challenge; it is also the quality and the reliability of the care that is provided. A large study from the USA reported that the ‘defect rate’ in the technical quality of American health care is 45%; in other words, only 55% of patients received the recommended care.\(^{10}\) In The Netherlands, it has likewise been estimated that 30–40% of health care is not based on best available scientific evidence.\(^{11}\) Consequently, quality critical care and anaesthesia are dependent on two variables, namely knowledge into action and reliability.

### Translating knowledge into action

Knowledge translation is the process by which results from research are put to use in routine practice. It is the use of knowledge in health-care decision making as outlined by Straus and colleagues,\(^{12}\) namely creating, acquiring, and disseminating knowledge, to manage and expedite the flow of knowledge into practice. It helps to clarify the distinction between efficacy (demonstrated in clinical trials; i.e. results achieved in rigorously controlled conditions in carefully selected patients) and clinical effectiveness (experienced in day-to-day practice, where unselected patients are managed in variable conditions).

Translating knowledge into action is thus the provision of ‘know-what’ (i.e. validated evidence and guidance for safe and effective care) and ‘know-how’ (i.e. evidence about effective implementation methods). This combination of knowledge about interventions and about implementation helps to create more reliable health care that is safe, effective, and person-centred. Improved critical care outcomes depend as much on knowledge from practice and experience as on published research knowledge. ‘Know-what’ helps the physician to answer the question, ‘Does this intervention work?’ ‘Know-how’ answers the question, ‘How do I make it work better here, for my patients?’

An interesting model proposed to ensure knowledge translation to improve health care in the USA is the ‘3Ts’ road map.\(^{13}\) The three steps are Translation 1 (T1), Translation 2 (T2), and Translation 3 (T3). Translation 1 comprises activities that test what works or clinical efficacy research to determine which intervention is effective, T2 consists of activities that focus on patient-specific evidence of clinical effectiveness or outcomes research, and finally, T3 consists of activities that test delivery of the intervention reliably and in all settings. Translation 3 includes measurement and evaluation of quality, implementation of interventions, and health-care redesign, scaling, and spread of effective designs.

There are many barriers to successful implementation, and these can be mapped into three main domains: knowledge; attitudes and behaviour, including lack of awareness of evidence, lack of familiarity, lack of agreement, lack of belief in self-efficacy, and lack of motivation; and organizational or environmental barriers. Rubenfeld and colleagues\(^{14}\) surveyed nurses and respiratory therapists in the institutions that participated in the ARDS network study\(^{15}\) and identified barriers to both initiation and continuation once commenced. Barriers to initiation included physician reluctance to relinquish control over ventilator adjustments, failure of recognition of acute lung injury/ARDS, and difficulty with calculating low tidal volume based on PBW. Barriers to continuation included concerns over patient distress, permissive hypercapnia, and the permissive oxygenation (acceptance of oxygen saturations of 88%) observed with low-tidal volume ventilation.

The study by Bourdeaux and colleagues\(^{9}\) perhaps addresses some of these barriers, namely the reluctance of physicians to relinquish control by allowing them to retain the reins of ventilator settings, simplification of the process of calculating 6 ml kg\(^{-1}\) tidal volumes based on PBW, and finally, removing a few steps from the recognition that the tidal volume is elevated in the decision-making process.

The crucial rate-limiting step in knowledge translation is the care delivery or implementation. Traditional processes, such as advice and feedback, care pathways, protocol use, or practice guidelines, are at best modestly effective in critical care because these initiatives target the problem too far downstream after the event. The critical care environment has been identified as a complex adaptive system, not unlike the stock market, where performance hinges more on the dynamic interactions of the adaptable elements (i.e. the team rather than the contribution of each individual). A complex adaptive system is an interactive structure with adaptable elements that have the freedom to act unpredictably and where the relationships of the elements are not the sum of individual static entities. The greatest strength of such a system is resilience in the face of adversity. Failure to adopt high-quality evidence can therefore be viewed through a systems thinking lens as an organizational problem rather than an individual problem. Solutions that focus on changing organizational factors, such as culture, communication, and the working environment, would consequently be more effective in implementation and ensuring reliability.

### Reliable design

A good operational definition of reliability in health care is ‘failure-free operation over time’,\(^{15}\) and this is something that we continually strive for in both anaesthesia and critical care. In fact, the critical care community has a proven track record with regard to the success of reliable health care, namely, the Ventilator Associated Pneumonia (VAP),\(^{16}\) central line-associated bloodstream infection (CLABSI),\(^{17}\) and Sepsis bundles.\(^{18}\)

In the aforementioned article by Bourdeaux and colleagues,\(^{9}\) the authors show a significant increase in compliance with evidence-based controlled mechanical ventilation, with the time spent with tidal volumes <6 ml kg\(^{-1}\) increasing from 17.5 to 28.6%. So, why is it, some 15 years after the publication of this landmark ARDS network trial,\(^{1}\) that we are still achieving reliable protective lung ventilation only one in four times, even with the help of technology? Well, health care is increasingly complex; indeed, the Institute of Medicine described it as one of the ‘most complex of human endeavours’.\(^{19}\) Current performance improvement methods are highly dependent on training and education, with an over-reliance on vigilance and hard work. We have a tendency to focus on benchmarked outcomes, thereby exaggerating the reliability within health care, giving both clinicians and leadership a false sense of security. The evidence of
harm from not following lung-protective ventilation is not tangible, with the outcome not immediately linked to the process. Finally, we rarely use deliberate design to achieve reliability goals, making it easy to do the right thing and difficult to do the wrong thing.

The Institute for Healthcare Improvement has a three-step model for applying principles of reliability to health-care systems,13 as follows: (i) prevent initial failure using intent and standardization (e.g. VAP bundle); (ii) identify failure when it occurs and intervene before harm is caused (e.g. World Health Organization Surgical Safety Checklist) or mitigate the harm caused by failures that are not intercepted with a back-up plan or contingency function (e.g. plan B in a failed intubation); and (iii) measure and then communicate learning from defects back into the design process (real-time assessment with root cause analysis).

The study by Bourdeaux and colleagues9 is a potentially promising example of the first two steps of the Institute for Healthcare Improvement reliable design model. However, in order to achieve process reliability for lung-protective ventilation of 80–90% and above, further work needs to be done. The public and transparent display of clinical information, such as the one by Bourdeaux and colleagues,8 in combination with computerized support decision making, real-time feedback of data, staff briefings, staff education as to the ‘know-why’ or ‘know-what’ of protective lung ventilation alongside other quality-improvement interventions, and a reliable design strategy will make it easy to do the right thing and difficult to do the wrong thing when it comes to lung-protective ventilation.

Declaration of interest
K.D.R. is critical care faculty for the Institute for Healthcare Improvement, Cambridge, MA, USA.

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